I. PROCEDURE SUMMARY

- This Procedure is established for determining the Net Dependable Capability of generating units within the Entergy Fossil Operations Business Unit and establishing a system of records so that changes in seasonal capability during the life of the equipment can be recognized.
- This Procedure defines the framework under which the net dependable capabilities are to be established.
- It is intended that the terms defined and the net dependable capabilities established pursuant to this Procedure shall be used to determine seasonal capabilities and that these seasonal capabilities shall be used for operations, planning, and billing according to the System Agreement.
- The Net Dependable Capability (NDC) of each unit will be calculated following this Procedure. Within the unit seasonal capability process, however, the direct role of the NDC will be limited to that of a reference point for understanding the current level of unit seasonal capability.
- All employees, agents and contractors of Entergy shall immediately report known, suspected or potential violations of this Procedure by following the procedures described in the Reporting Violations Policy.
- Refer to the following detailed Procedure for further Information.
- This procedure is for all Fossil Operations units including Hydroelectric.

REVISION INDEX

Revision	Section Revised	Comments	Date
0	NA	Initial Issue	*8/28/2007*
1	Whole Procedure	Changed whole procedure to new format, deleted generic responsibilities, deleted unnecessary sections that were covered in other procedures. Changed Title and words “Fossil Fired Units” to “Fossil Business Units” throughout procedure.	1/14/2010
	7 and attachments	Removed boiler heat release calculations Added sections to include testing and corrections for hydro units. Specified day of month to seasonal spans.	
	4	Added a plant manager responsibility to identify the cause of MW losses	

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Title: Net Dependable Capability Test Procedure for the Fossil Operations Business Unit

Manager, Fossil Compliance	1/18/2010 Date
Manager, Operations and Technical Support	1-18-10 Date
Director, Northwest Region	1/19/10 Date
Director, Southeast Region	1/19/10 Date
Director, Central Region	1/19/10 Date
Vice President, Power Plant Operations	1/20/10 Date
Senior Vice President, Fossil Operations and Supply Chain	1/21/10 Date

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II. TABLE OF CONTENTS

III. DETAILED PROCEDURE

1.0 PURPOSE

The purpose of this procedure is to provide a standard for determining the Net Dependable Capability (NDC) real power rating of units within Entergy's Fossil Business Unit The procedure defines the framework under which the rating is to be established while recognizing the necessity of exercising judgment in its determination.

It is intended that the NDC rating established pursuant to this procedure shall be consistent with the NERC/SERC requirements and shall be used for planning, dispatching, maintenance scheduling, and the preparation of information for industry organizations, news media and governmental agencies.

2.0 SCOPE

This procedure is to be used for testing generating units in the generation plan of the Entergy Fossil Business Unit for real power capability.

Adjustments to the measured capability will be allowed for seasonal variations in ambient temperature, seasonal variations in condenser cooling water temperature, and certain variations from design steam pressures and temperatures.

3.0 BACKGROUND

The NDC rating established pursuant to this procedure shall be consistent with the NERC reliability standards as defined by MOD 024-1 (Verification of Generator Gross and Net Real Power Capability) requiring the determination of or a reporting of generating unit MW capabilities by the Generator Owner or Generator Operator.

4.0 REFERENCES

4.1 Verification of Generator Gross and Net Real Power Capability (MOD – 024-1)

4.2 Verification of Real Power Capability Procedure (EF-PR-NERC-02)

4.3 Unit Seasonal Capability Updating Process (EF-PR-NERC-14)

4.4 Methodology for Rating Generation Facilities (EF-PR-NERC – 16)

5.0 DEFINITIONS

5.1 Net Dependable Capability(NDC) - The net generation (gross output less power used for auxiliaries and other station requirements) the unit can sustain during a predetermined test duration corrected to conditions as defined in this procedure, with no equipment, operating, or regulatory restrictions outside of what would be considered normal for the particular generating unit.

5.2 Seasonal Capability - The maximum net generation the System Planning Organization (SPO) can expect to obtain from a generating unit during the subject season at least 80% of the time when called upon. This Seasonal Capability is projected by plant management, taking into account the previous season's performance and the project condition of the generating unit during the upcoming season. There are two seasons defined by this process, winter and

summer. The winter season spans from October 1 through April 30. The summer season spans from May 1 through September 30.

6.0 RESPONSIBILITIES

6.1 Manager, Plant

6.1.1 Ensures compliance at his/her facilities with requirements for testing units and determining Seasonal Capabilities.

6.1.2 Responsible for initiating an NDC test after unit modifications or upon request by qualified entities.

6.1.3 Responsible for coordinating unit test schedule with the SPO and Regional Plant Support Group prior to the summer season (desired) or winter season if required. Test may be canceled at any time by plant management, if plant personnel suspect that the unit's condition does not represent expected operating conditions, or for any other reasons.

6.1.4 Responsible for noting any operations or plant equipment condition that limits the unit from obtaining its current seasonal rating or full load operating conditions.

6.1.4.1 Example limitations may include but are not limited to FD Fan limits, BFP limits, fuel flow, environmental emissions, condenser back pressure, air heater limits, turbine efficiency, FWH tube failures, etc. If the unit is operating at maximum expected capability with no known limitations, the unit limitation may be noted as "No abnormal equipment limitations" or ."Operating at Max Capability with Valves Wide Open at design conditions may be noted as "VWO limitation at design conditions".

6.2 Manager, Operations & Technical Support(O&TS)

6.2.1 Upon request by Plant Management, O&TS can perform an analysis of actual unit operations using data from the PI archive data base. Data shall be corrected to summer and winter seasonal capabilities as defined by this procedure.

6.2.2 The O&TS will forward results to the SPO and/or requesting entities after the Plant Manager has approved the results.

6.2.3 Archive holder of Fossil O&TS generator capability records. All test data, analysis, and final test reports shall be retained for the most current and prior verifications.

6.2.4 Responsible for updating and revising this procedure as necessary.

6.3 Engineer, Regional Plant Support Group

6.3.1 Tests may be performed by the Regional Plant Support Group if requested by the Plant Manager. Test data may be collected using calibrated test instrumentation or PI data. Test data shall be corrected to summer and winter Seasonal Capabilities as defined by this procedure.

6.3.2 All test results shall be submitted to the Plant Manager and OT&S within two weeks of the test for review and approval. The OT&S will review results for accuracy and forward to the SPO and/or requesting entities after the Plant Manager has approved the results

7.0 .DETAILS

7.1 TESTING FREQUENCY

7.1.1 Initial capability tests shall be conducted on all operating units subsequent to the adoption of this procedure. Capability tests shall be conducted on new units and units new to the Entergy system.

7.1.2 Unit role will be used to determine the schedule for conducting the initial NDC tests. Scheduling priority will be given to the base-load and load-following units while the remaining units will be tested as manpower and unit operations permit. Additional tests will be conducted following major maintenance outages where significant unit modifications were made such as major boiler tube section replacements with upgraded materials, major turbine inspections (repairs), elimination of long term load limiting conditions due to plant equipment degradations, or upon request by the SPO or plant management.

7.2 TEST CONDITIONS

7.2.1 When possible, the NDC should be determined during the period when the system peak is most likely to occur, typically but not limited to June through September corrected to the maximum summer and/or winter season ambient temperature conditions. Units will not be committed for sole purpose of conducting a capability test, therefore, units will only be tested when operating to meet system capacity needs.

7.2.2 Each plant is responsible for confirming the NDC of its units on both a winter and summer basis by either scheduling a unit capability tests in accordance with this procedure or by requesting an analysis of actual unit operations using data from the PI archive data base or a combination of the two. The NDC rating for each generating unit shall be established based on the results of either analysis method

7.2.3 The stated MW capability of each generating Facility will be inclusive of components comprising that facility. Facility Rating will not exceed individual component ratings

7.2.4 All equipment required for normal operations shall be in service and operating normally. Real Power consumption by common service load, if not already measured by the auxiliary watt hour metering, (for example, coal-handling or lighting) will be prorated among the appropriate units in the plant and will represent the consumption normally experienced during the high-load period of the day. Discretion may be used when estimating station service for small, unmanned hydro and internal combustion stations where station service is not accurately metered and/or recorded on an hourly basis.

7.2.5 The gross and net continuous capability shall be determined separately for each generating unit in a power plant if the maximum net output of each unit is independent of the others. Two (2) or more units in a single station and/or two (2) or more stations whose capability is limited by common elements and/or commonly assigned staff shall have their capabilities determined recognizing the limitation of those common elements [e.g., staffing, steam headers, stacks and other boiler auxiliaries, condenser cooling equipment (e.g., spray modules, pumps, screens, inlets, discharge canals, cooling towers), common river flows, head and tailrace water levels, common penstock, watershed, etc.]. Each unit will be assigned a rating by apportioning the combined plant(s) capability among the affected units.

7.3 TEST DURATION

7.3.1 Rankin Cycle Units and Combined Cycle Unit

7.3.1.1 The net dependable capacity test shall be conducted for four continuous hours and shall not start until stable full load operating conditions are reached.

7.3.2 Combustion Turbines

7.3.2.1 The net dependable capacity test shall be conducted for two continuous hours and shall not start until stable full load operating conditions are reached.

7.3.3 Hydro Units

7.3.3.1 The net dependable test shall be conducted for two continuous hours and shall not start until stable full load operating conditions are reached.

7.4 UNIFORM TEST AND RATING CONDITIONS

7.4.1 Rankine Cycle Units

7.4.1.1 Test Conditions - Tests shall be conducted with the unit operated within the design limits of its individual components so that the first component reaching its limit will be the limiting factor for the unit. Over pressure operation is not permitted. Judgment must be used in selecting the final test conditions such that the normal operating limits of auxiliary equipment are not exceeded. Any actual or impending equipment operating limit should be recorded. Test conditions should be selected to minimize the applied corrections to net generation. Tests should be conducted as close to design main and reheat steam temperatures and main steam pressure.

7.4.2 Gas Turbine & Combined Cycle Units

7.4.2.1 Test Conditions - Tests shall be conducted with all equipment in service with “Base Load” selected for the gas turbines. Combined cycle units with supplemental firing capability shall have the duct burners in operation. Inlet cooling equipment

shall be in service based on normal operating practices. Main and reheat steam temperatures should be as close as possible to design conditions to minimize corrections to net generation .

7.4.3 Hydro Units

7.4.3.1 Test Conditions - Tests shall be conducted with the unit operated within the design limits of its individual components so that the first component reaching its limit will be the limiting factor for the unit. Any actual or impending equipment operating limit should be recorded. Test conditions should be selected to minimize the applied corrections to net generation. Tests should be conducted as close to normal lake and tailrace elevations.

7.4.4 All Units

7.4.4.1 Environmental - When the total output of a plant is reduced due to restrictions placed upon the output of individual generating units through the operation of the Clean Air Act, or similar legislation, then the unit's NDC rating shall be limited to the restricted output.

7.4.4.2 Fuel- The fuel used during testing shall be the primary fuel used during the year.

7.5 AMBIENT CONDITIONS AND COOLING WATER TEMPERATURE

7.5.1.1 Condenser Cooling Water Temperature

7.5.1.2 Summer - The Average Maximum Condenser Cooling Water Temperatures summer, AMCCWT, is the average of the daily maximum temperatures from May 1 thru September 30 for the source of cooling water. The capability will be based on the condenser back pressure corresponding to this AMCCWT.

7.5.1.3 Winter - The Average Maximum Condenser Cooling Water Temperatures winter, AMCCWT, is the average of the daily maximum temperatures from October 1 thru April 30 for the source of cooling water. The capability will be based on the condenser back pressure corresponding to this AMCCWT.

7.5.1.4 For units equipped with cooling towers, the AMCCWT is estimated by using the cooling tower manufacturers' curves and the best available summer or winter historical data on wet bulb temperatures. Appendix D describes the method of determining the AMCCWT using test data and historical wet bulb temperature data.

7.5.2 Combustion Turbine Inlet Air Temperature

7.5.2.1 Summer -The "Average Maximum Compressor Inlet Air Temperature", AMCIAT, is the average of the daily maximum ambient dry-bulb temperatures in May 1 – September 30 for the corrected ambient air temperature. The capability will be based on the compressor inlet air temperature corresponding to this AMCIAT.

7.5.2.2 Winter -The "Average Maximum Compressor Inlet Air Temperature", AMCIAT, is the average of the daily maximum ambient dry-bulb temperatures in October 1 thru April 30 for the corrected ambient air temperature. The capability will be based on the compressor inlet air temperature corresponding to this AMCIAT.

7.6 REPORT AND OUTPUT CORRECTIONS

7.6.1 The output report will contain at a minimum the following:

7.6.1.1 Seasonal gross and net real power generating capabilities

7.6.1.2 Real power requirements for auxiliary loads

7.6.1.3 Weather, ambient air and water conditions, fuel quality and quantity.

7.6.1.4 Method of validation including date and conditions. If no special or unusual line ups or conditions apply then the condition will be recorded as “normal”.

7.6.1.5 Reason for load limit

7.6.2 Steam Turbines - The test should run as near to design conditions as possible in order to minimize the correction factors. Corrections for deviations from design main steam pressure, main steam temperature, and reheat steam temperature shall be obtained from the turbine manufacturer's curves.

7.6.2.1 Main Steam Pressure Corrections - Corrections resulting in increases in capability will be allowed up to 1 % deviation from design conditions. For example, if 3500 PSIG is design throttle pressure, and the test is run at an average pressure less than 3465 PSIG, no pressure correction will be allowed. Corrections which result in decreases in capability shall be applied to the full amount for initial steam pressure.

7.6.2.2 Main Steam or Throttle Temperature – Data taken at the Boiler or turbine will be corrected to design conditions. Corrections which result in increases in capability will be allowed up to 10 deg F deviation from design conditions. For example, if 1000 deg F is the design throttle temperature, and the test is run at an average temperature above 1010 deg F, no temperature correction will be allowed. Corrections which result in decreases in capability shall be applied to the full amount from the measured steam temperature to design.

7.6.2.3 Reheat Steam Temperature – – Data taken at the Boiler or turbine will be corrected to design conditions. Corrections which result in increases in capability will be allowed up to 10 deg F deviation from design conditions. For example, if 1000 deg F is the design throttle temperature, and the test is run at an average temperature below 990 deg F, no temperature correction will be allowed. Corrections which result in

decreases in capability shall be applied to the full amount from the measured RH steam temperature to design.

7.6.3 Backpressure - The correction of adjusting the back pressure to AMCCWT shall be determined using the turbine manufacturer's curves and the method described in Attachment 4 using test data and unit design constants.

7.7 Combustion Turbines - The test should run as near to design conditions as possible in order to minimize the correction factors. Corrections for deviations from normal for maximum turbine exhaust temperature shall be obtained from the turbine manufacturer's curves. Corrections which result in capability increases will be limited to an amount less-then or equal-to a 1% deviation from the design conditions. For example, if 1000 °F is design exhaust temperature and the test is run at 950 °F, a correction will be allowed from 950 °F to 960 °F only. Corrections which result in decreases in capability must be applied to the entire deviation.

7.7.1 The correction of adjusting the compressor inlet air temperature to AMCIAT can be determined using the turbine manufacturer's curves. .

7.7.2 Units with virtual plant models can be tested utilizing the models tuned to current operating conditions and then adjusted to AMCIAT and humidity conditions.

7.8 Hydro Units – The test should be run as near to normal lake and tailrace elevations to minimize power corrections to a common head. In the event corrections for head are required, utilized the following equations. Assumed internal head loss is negligible.

HT = Net Head Test = Lake elevation – discharge (tailrace) elevation

HR = Net Head Reference Net MWT = Net Generation Tested

Net MWT = Net Generation Tested Net MWc = Net Generation Corrected

$$\text{Net MWc} = \text{Net MWt} \times (HR/HT)^{1.5}$$

8.0 RECORDS

8.1 The Manager of Operations and Technical Support is administratively responsible for this procedure.

8.2 Previous revisions of this procedure must be kept for one year past the date or the revision; keep all documented comments from external entities on the procedure and responses for 3 years. All documents related to a finding of non-compliance will be maintained until found to be compliant. Retain internal documents comments only until resolution of the comment.

8.3 This Facility Ratings Methodology will be available for inspection and technical review by those Reliability Coordinators, Transmission Operators, Transmission Planners, and Planning Authorities that have responsibility for the area in which the associated Facilities are located, within 15 business days of receipt of a request.

8.4 If a Reliability Coordinator, Transmission Operator, Transmission Planner, or Planning Authority provides written comments on its technical review of a this Facility Ratings Methodology, a written response will be provided to that commenting entity within 45 calendar days of receipt of those comments.

8.4.1 The response shall indicate whether a change will be made to the Facility Ratings Methodology and, if no change will be made to that Facility Ratings Methodology, the reason why.

8.5 The following will be available for inspection during an onsite audit by the compliance monitor or within 15 business days of receipt of a request as part of an investigation upon complaint.

8.5.1 The facilities rating methodology.

8.5.2 Superseded portions of the facilities rating methodology made within the last 12 months.

8.5.3 Documented comments made by a Reliability Coordinator, Transmission Operator, Transmission Planner or Planning Authority on its technical review of the facility ratings methodology.

8.6 This procedure will be revised only at the direction of Manager Operations And Technical Support or Manager Compliance

8.7 All test data, analysis, and final test reports shall be retained for the most current and prior verifications

8.8 Office of Records numbers and custodians for related documents as follows

8.8.1 No. 1482 for capability test results, seasonal ratings data or transmittals and other ratings documentations originating from Operations and Technical Support (O&TS). Custodian will be at Operations and Technical Support.

8.8.1.1 The plant will be custodian for these type documents originating from a plant.

8.8.2 No. 2160 for correspondence on data requests and transmittals received or transmitted from O&TS. Custodian will be O&TS.

8.8.2.1 The plant will be custodian for these type documents originating from a plant.

8.8.3 No. 1976 for this and other procedures. O&TS is the custodian of the procedures.

9.0 ATTACHMENTS

9.1 Generating Unit Facility Rating Methodology flow chart

9.2 Attachment 1 : Sample Report Forms

xz**Bulb Correction Calculations**

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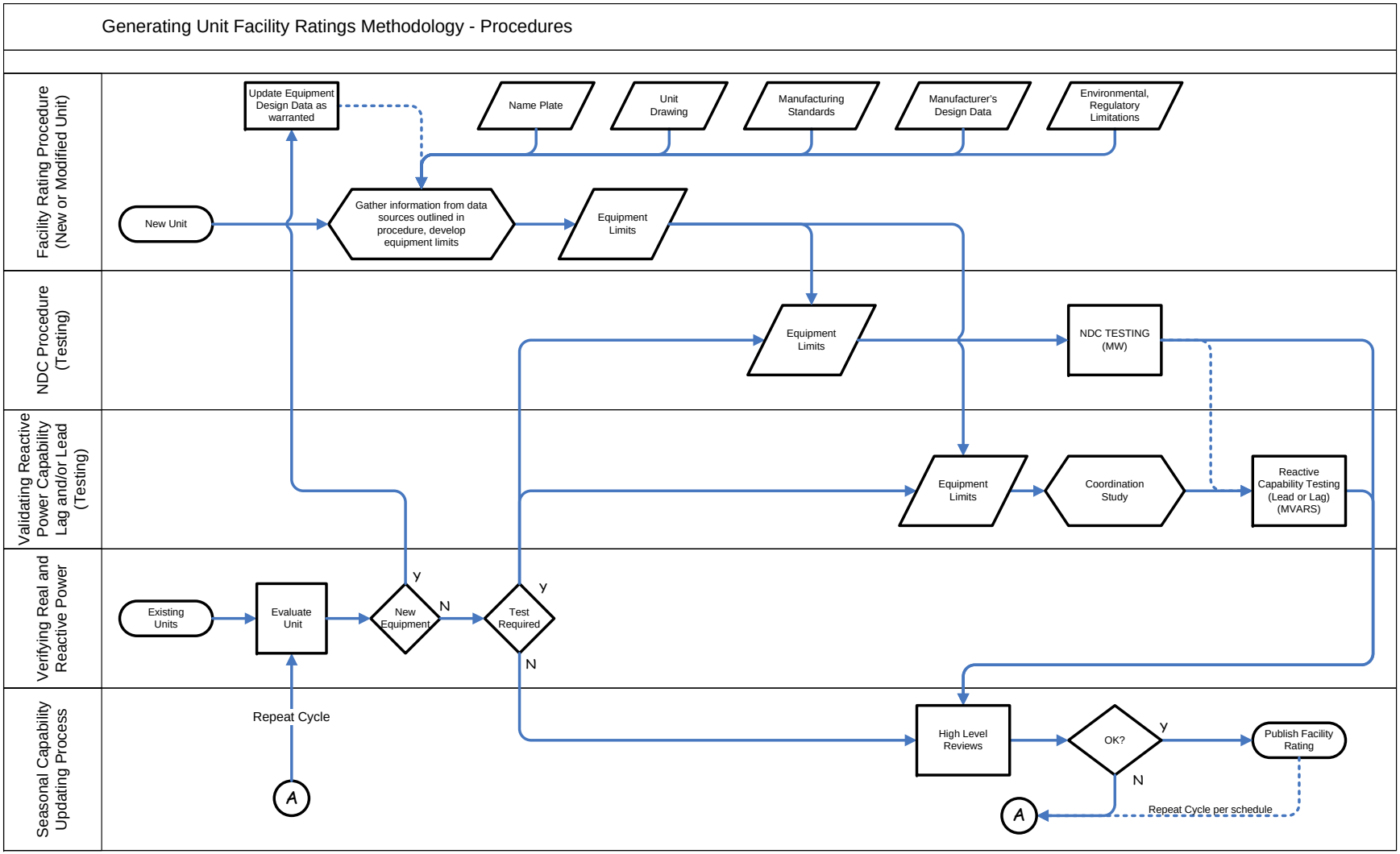
Generating Unit Facilities Rating Methodology Flow Chart



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Attachment 1- a. Sample Rankine Cycle O&TS Automated Program Utilizing PI Data Report Form

Entergy Fossil Verification of Generator Real Power Capability
Test Data and Calculations

Generating Unit:	
Test Date:	
Test Start Time:	
Test End Time:	
Conducted By:	

Parameter	units	Test	Standard	Dev
Main Steam Temperature	degF			
Main Steam Pressure	psig			
Reheat Temperature	degF			
Circulating Water In Temp	degF			-
Circulating Water Out Temp	degF		-	-
Turbine Backpressure	inHgA		-	-
Dry Bulb Temperature	degF		-	-
Ambient Temperature	deg F			

Final Corrections		Test	Low Limit	Allowance	LCD*
Main Steam Temperature	dev, degF				
Main Steam Pressure	dev, %				
Reheat Temperature	dev, degF				
Backpressure	inHga				
Total Correction Divisor					

*Load Correction Divisor

Gross Generation	Mw	
Station Service	Mw	
Net Generation	Mw	

Adjustment for MS Temp	Mw	
Adjustment for MS Press	Mw	
Adjustment for RH Temp	Mw	
Adjust for Backpressure	Mw	
Sum of Mw adjustments	Mw	

Corrected Net Gen	Mw	Current Declared 08_09 Winter Rating	Mw

Deviation	%	

To Be Completed By Plant Management Only

MW Capability Limited By:	
Approved By:	

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Attachment 1- b.Sample Combine Cycle 2X1 Unit Report Form- Utilizing Virtual Plant Model

Entergy Fossil Verification of Generator Real Power Capability
Test Data and Calculations

Generating Unit:	
Test Date:	
Test Start Time:	
Test End Time:	
Conducted By:	

Parameter	Units	Actual Test	VP Model
Main Steam Temperature	degF		
Main Steam Pressure	psig		
Reheat Temperature	degF		
Circulating Water In Temp	degF		
Circulating Water Out Temp	degF		
Condenser Pressure	inHgA		
Fogger Amb Dry Bulb Temp	degF		
Fogger Amb Wet Bulb Temp	degF		
Barametric Press	psia		
Ambient Relative Humidity	%		

Final Corrections		Actual	VP Model
CT1-1 Power Output	Mw		
Stm Turb Gen Output	Mw		

Gross Generation	Mw		
Station Service	Mw		
Net Generation	Mw		

Corrected Net Gen Test Value	Mw	Current Declared 10 Summer Rating	Mw

Deviation	%	

To Be Completed By Plant Management Only

MW Capability Limited By:	
Approved By:	

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Attachment 1- c. Sample Gas Turbine Unit Report Form

Entergy Fossil Verification of Generator Real Power Capability
Test Data and Calculation

Generating Unit:	
Test Date:	
Test Start Time:	
Test End Time:	
Conducted By:	

GT THERMAL KIT CORRECTIONS (KW)			TEST	DESIGN	PERCENT CHANGE	Divisor
GT Compressor inlet Temp		deg F				
Ambient Pressure		psia				
PRODUCT OF CORRECTION DIVISOR						

ST THERMAL KIT CORRECTIONS						
Initial pressure		psig				
Initial temperature		deg F				
GT Compressor inlet Temp		Deg F				
PRODUCT OF CORRECTION DIVISOR						
Back Pressure Load Correction		In HgA				

Average GT Gross Generation (test)	MW	
Average ST Gross Generation (test)	MW	
Average Auxiliary Usage (test)	MW	

Corrected GT Gross Generation	MW	
Corrected ST Gross Generation	MW	
Average Auxiliary Usage (test)	MW	
Corrected Net Generation	MW	

Corrected Net Gen	MW	Current Declared 08 Summer Rating	MW

Deviation	%	

To Be Completed By Plant Management Only

MW Capability Limited By:	
Approved By:	

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Attachment 1 - d. Sample Hydro Unit Report Form

Entergy Verification of Generator Real Power Capability For Hydro Units
Test Data and Calculations

Generating Unit:	
Test Date:	
Test Start Time:	
Test End Time:	
Conducted By:	

Test Head, H_T Calculation	**Units**	**Start**	**End**	**Average**
Head Water Elevation	Ft			
Tail Water Elevation	Ft			
Test Head, H_T	Ft			

Reference Head, H_R Calculation		
Head Water Elevation	Ft	
Tail Water Elevation	Ft	
Reference Head, H_R	Ft	

Gross Generation	Mw	
Station Service	Mw	
Net Generation, MW_T	Mw	

*Net Generation Corr., MW_C	Mw	

*Net MW_c = Net MW_t X $(H_R/H_T)^{1.5}$

Corrected Net Gen Mw	Current Declared 09 Summer Rating Mw

Deviation	%	

To Be Completed By Plant Management Only

MW Capability Limited By:	
Approved By:	

ATTACHMENT 2 : SAMPLE RANKINE CYCLE TEST FIELD DATA FORM

TEST DATA FORM
AVERAGE CONDITIONS FOR TEST

		Test	Design
Gross Generator Output	Mwh		
Auxiliary usage	Mwh		
Net Generation Output	Mwh		
Turbine initial pressure	psig		
Turbine initial temperature	°F		
Reheat temperature	°F		
Circulating water temperature – inlet	°F		
Circulating water temperature – outlet	°F		
Turbine exhaust pressures	In Hg		
Feedwater flow	Mlb/hr		
Fuel Flow	MMBtu/hr		
Barometric pressure	In Hg		
Ambient dry-bulb temperatures	°F		
Ambient wet-bulb temperatures	°F		

Test run at overpressure conditions?	(Y/N)	

ATTACHMENT 3: Manual Method to Perform Cooling Water Corrections

METHOD FOR CORRECTING UNIT CAPABILITY TESTS FOR THE DIFFERENCE BETWEEN ACTUAL COOLING WATER TEMPERATURE AND "AVERAGE MAXIMUM CONDENSER COOLING WATER TEMPERATURE"

I. Formula to be used:

$$LMTD\,(Std.) = LMTD\,(Test)\,x\,\frac{F_1(Test)}{F_1(Std.)} \qquad \textbf{(1)}$$

II. Symbols:

Q = Heat rejected to condenser- Btu/Hr
A = Area of condenser tube surface - Ft^2
U = Rate of heat transfer - $Btu/Hr/Ft^2/°F$
LMTD = Log Mean Temperature Difference - °F
Std. = Design Conditions
Test = Test Conditions
Tr = Temperature rise in circulating water- °F
Ts = Temperature of steam in condenser- °F
W = Circulating water flow - Lbs/Hr
V = Velocity of water in condenser tubes - Ft/Sec
F_1 = Heat transfer correction factor for circulating water inlet temperature
F_2 = Heat transfer correction factor for tube material and wall thickness
F_3 = Heat transfer correction factor for tube cleanliness
C = Condenser tube heat transfer constant.
AMCCWT = "Average Maximum Condenser Cooling Water Temperature" - Average of daily maximum temperatures in June, July, and August for the sources of cooling water during the past five year period.

III. Validation of Formula:

At 100% open turbine valves, the flow of steam to the condenser is assumed the same over the usual range of condenser vacuum. Since the turbine load correction factor from 1.5 to 3.5 " Hg backpressure varies at full load only about 0.5 to 0.75 of one percent on large turbines and since the heat used by the turbine is approximately half of that sent to the condenser, then the error in steam flow caused by assuming the heat rejected to the condenser remains constant will be less than 0.75% through this range of condenser back pressures. Since the same pumping system would be used, the amount of circulating water will be practically constant, therefore the following applies:

$$Tr = \frac{Q}{W}$$

Since Q and W are constant, then Tr is constant.
The formula for heat transfer through the condenser tube is:

$$Q = AxUxLMTD$$

or

$$\frac{Q}{A} = UxLMTD$$

Since Q and A are constant, then U x LMTD will be constant or the LMTD will vary inversely with U.

$$U = F1xF2xF3xCx\sqrt{V}$$

Standard formula for rate of heat transfer

Since the tube material will remain the same and the cleanliness can be assumed to remain constant and the circulating water flow is constant, then F_2, F_3, C and V are constant. Therefore, U varies directly with F_1. F_1 will vary with the inlet water temperature in accordance with the curve from HEI attached.

Then:

$$\frac{U(Test)}{U(Std.)} = \frac{F_1(Test)}{F_1(Std.)}$$

And since LMTD varies inversely with U

$$\frac{LMTD(Std.)}{LMTD(Test)} = \frac{U(Test)}{U(Std.)} = \frac{F1(Test)}{F1(Std.)}$$

or

$$LMTD(Std.) = LMTD(Test)x\frac{F1(Test)}{F1(Std.)}$$

IV. Application of Formula:

Full load test is run and readings are taken of generator output, circulating water temperatures in and out of condenser and the condenser backpressure. From the backpressure, the steam temperature can be obtained from the steam tables. The Log Mean Temperature Difference (LMTD) under test conditions can be calculated or referenced to charts from the above readings. Then from the attached HEI chart, the F, corrective can be obtained for the test conditions and also for the “Average Maximum Cooling Water Temperature” (AMCCWT).

Substituting the above values in formula (1), the LMTD under AMCCWT conditions can be calculated. Since the temperature of the circulating water inlet is known and the temperature rise is the same under test and standard conditions, then the temperature of the steam in the condenser for AMCCWT can be obtained from calculations or charts. With the steam temperature known, the corresponding condenser backpressure can be obtained. the corrected generator output can be obtained using the turbine manufacturer's curves.

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ATTACHMENT – 4 Manual Method to Perform Cooling Tower Wet- Bulb Corrections

USE OF WET-BULB TEMPERATURE IN ESTIMATING AMCCWT FOR RATING UNITS WITH COOLING TOWERS

Cooling towers are generally designed around five basic parameters. They are as follows:

1. Average maximum wet-bulb temperature
2. Average maximum dry-bulb temperature
3. Cooling water flow
4. Cooling range
5. Degree approach desired

The cooling tower manufacturer should furnish performance curves based on the above parameters with more than one cooling range curve. This will provide useful data and enable somewhat more accurate determination of the maximum cooling water temperature expected when the test is run at other than cooling tower design conditions.

The following is a description of the use of cooling tower performance curves to assist in determining the maximum cold water temperature to be used with the corrections when the test is run at other than design conditions. The capability test should be run as close to the tower design wet-bulb temperature as possible to eliminate errors when transferring from test to design conditions.

Determine from test data the cooling range.
If the cooling range does not fall on a curve established by manufacturer, an approximation curve must be sketched in to match existing curves. The approximation curve should be drawn in to follow the general slopes of the manufacturer's curves with some convergence at the higher wet-bulb temperatures.
At the test wet-bulb temperature, establish a point on the estimated or design cooling range curve. This point will determine what the cold water temperature should be if the tower is functioning properly.
If the test cold water temperature does not fall on the degree range curve, the estimated maximum water temperature can be obtained by adding or subtracting this difference to the cold water temperature obtained at the intersection of the design maximum wet-bulb and the estimated degree range curve. This temperature will be the approximate average maximum cold circulating water temperature to which the unit capability will be corrected.

If the local weather station is believed to be too far away or the data insufficient to use for wet and dry bulb temperatures, procedures and facilities may be set up at the station to obtain the necessary data.